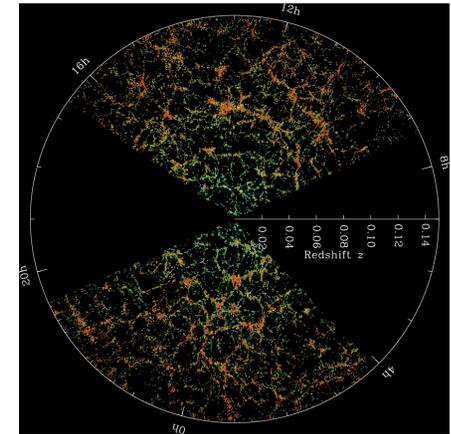
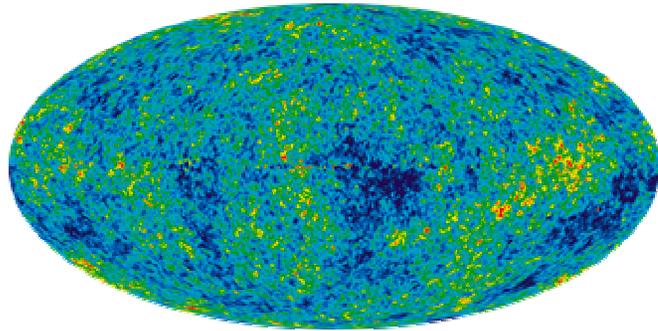


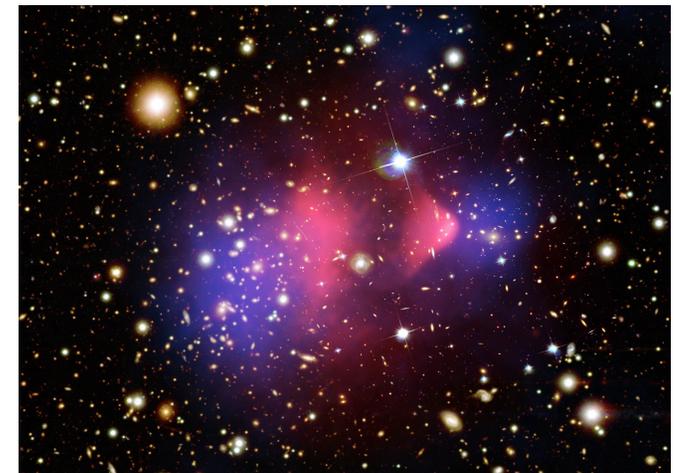
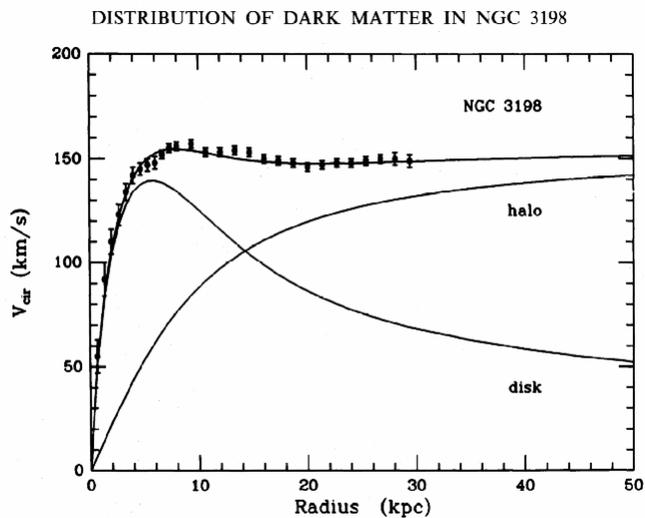


The Search for Dark Matter with HAWC



J. Patrick Harding
LANL

Santa Fe Cosmology Workshop
11 July 2013

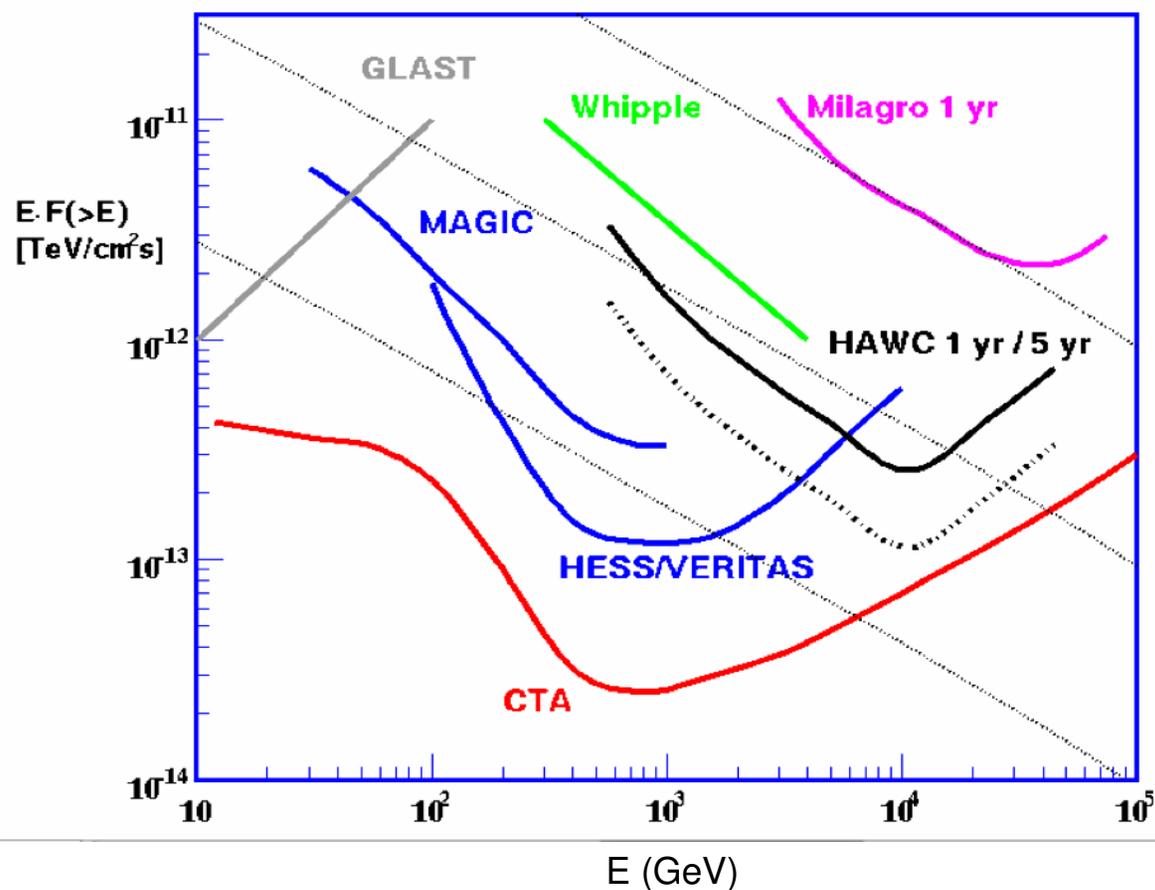




Altitude: 4100 m (13000 ft)

Latitude: 19° N

- Energy Resolution:
~50% from ~ 1TeV – 100 TeV
- Angular Resolution:
~0.25° – 0.5°
- Field-of-view:
2 sr (2/3 sky each day)
- Effective Area:
10⁴ – 10⁵ m²
- Sensitivity:
~ 10⁻¹⁴ cm⁻²s⁻¹ – 10⁻¹² cm⁻²s⁻¹

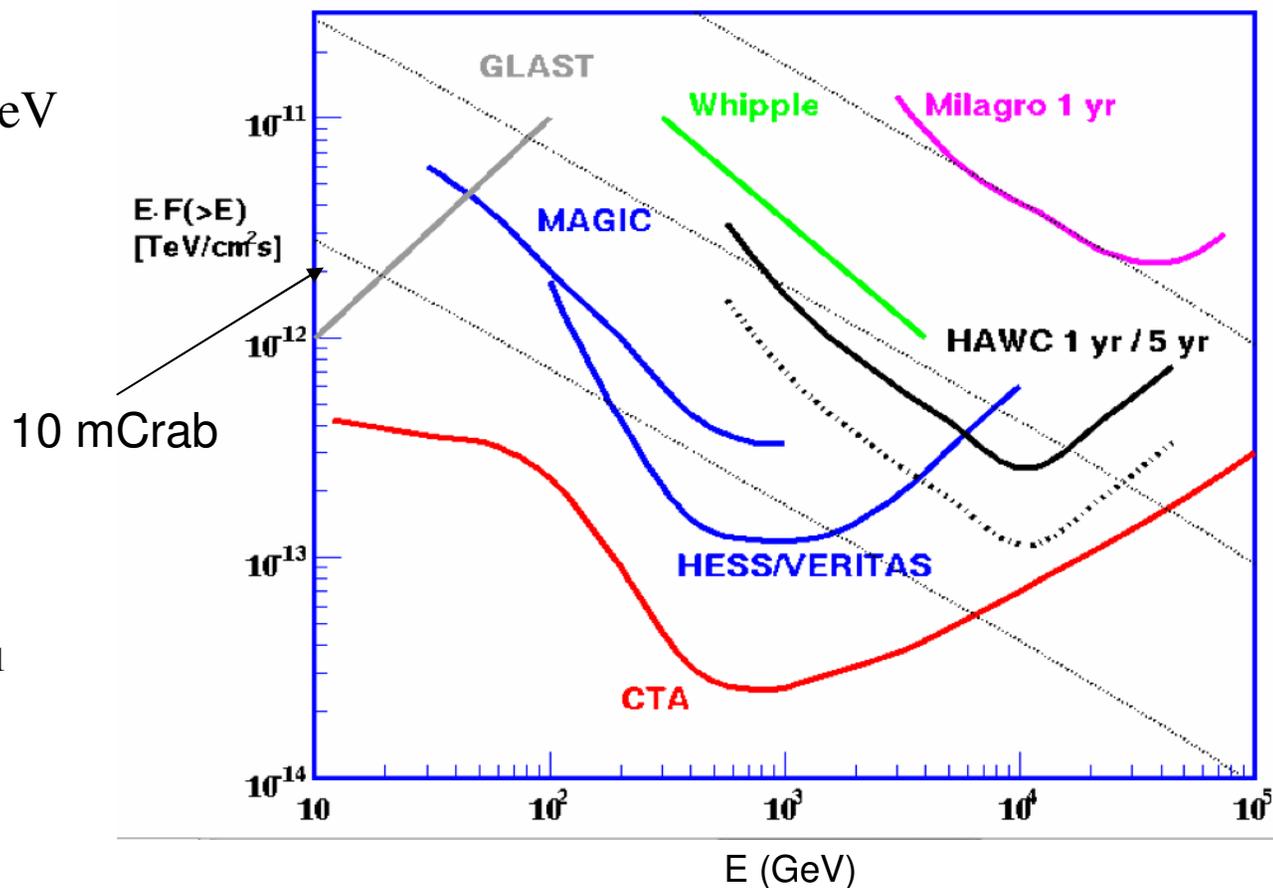


HAWC Sensitivity

100 mCrab

1 Crab

- Energy Resolution:
~50% from ~ 1TeV – 100 TeV
- Angular Resolution:
~0.25° – 0.5°
- Field-of-view:
2 sr (2/3 sky each day)
- Effective Area:
10⁸ – 10⁹ cm²
- Sensitivity:
~ 10⁻¹⁴ cm⁻²s⁻¹ – 10⁻¹² cm⁻²s⁻¹

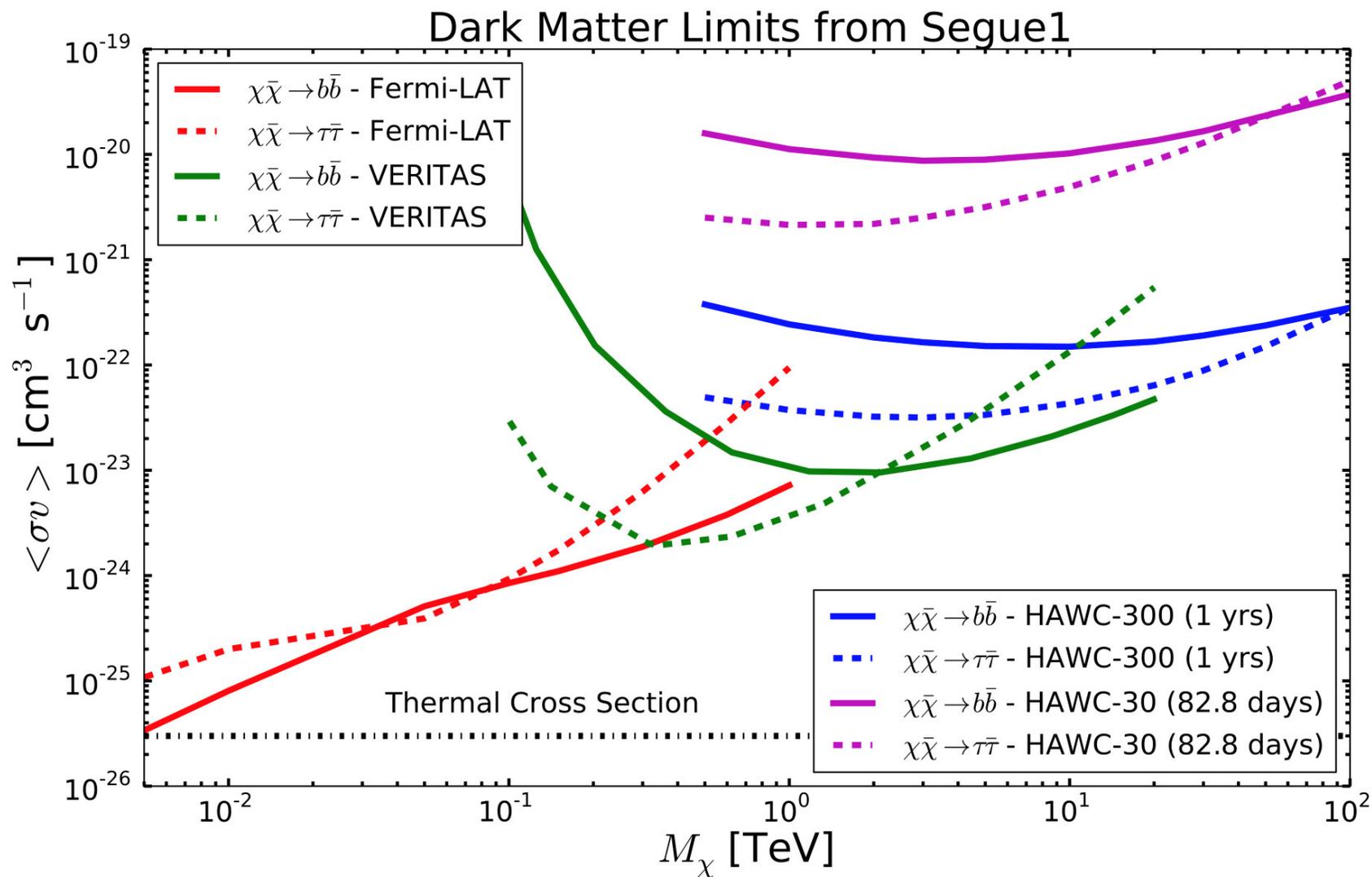




HAWC DM Sources

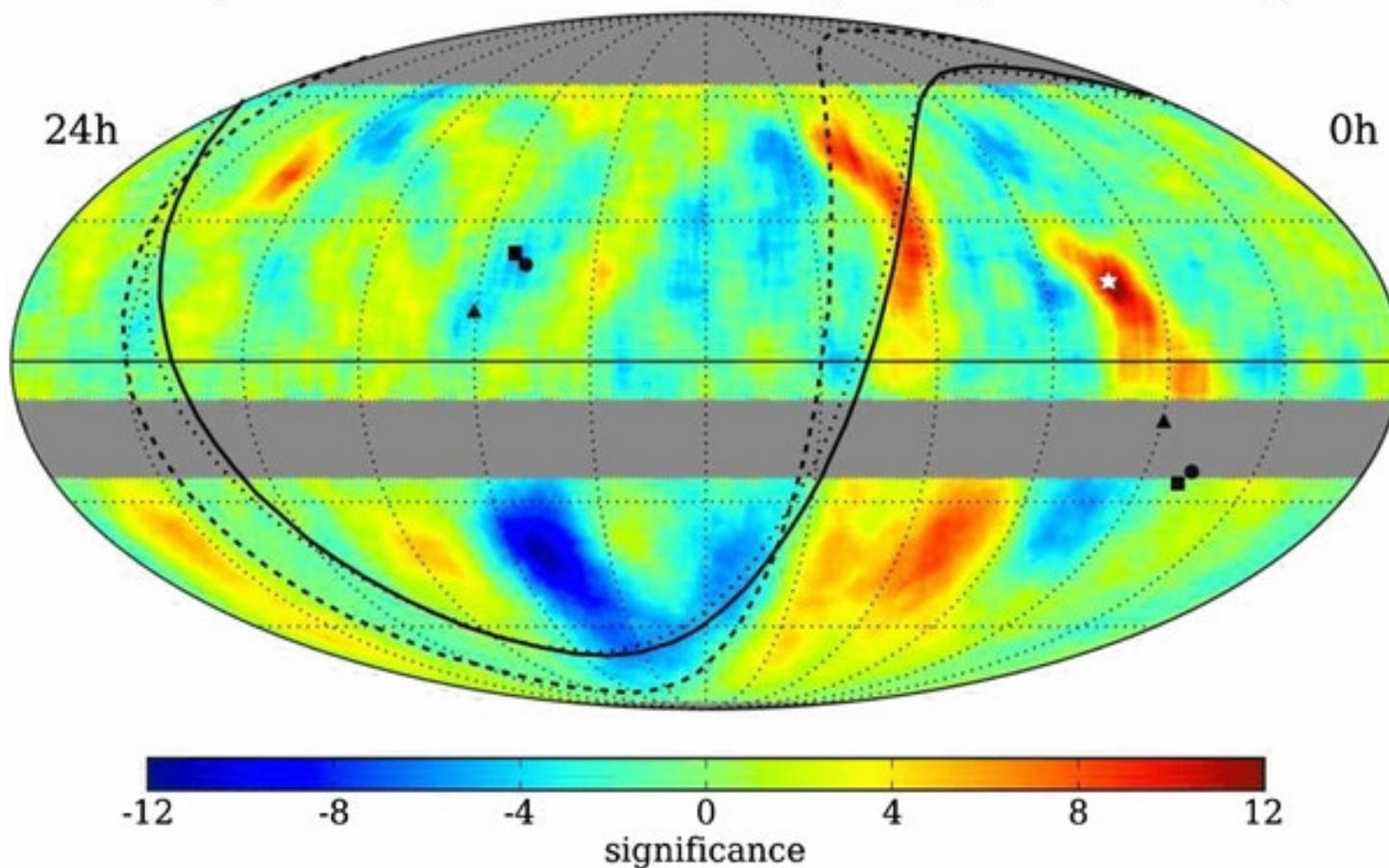


- Dwarf galaxies
 - Known and *unknown*
 - Can stack them (see David's talk)
- Other galaxies
- Galactic center
- Galaxy clusters
- Diffuse gamma-ray background



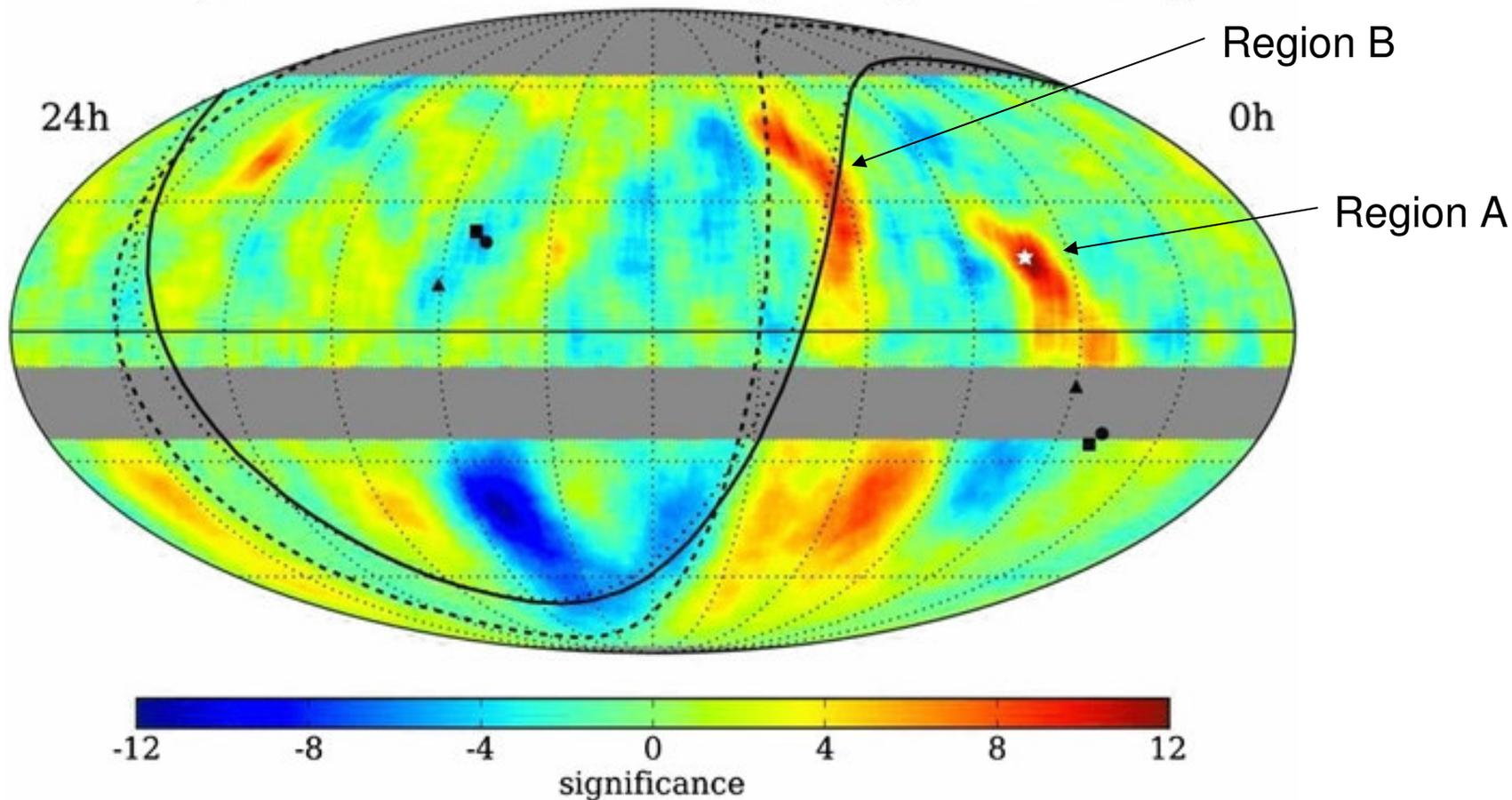
TeV CR Anisotropy

Milagro + IceCube TeV Cosmic Ray Data (10° Smoothing)

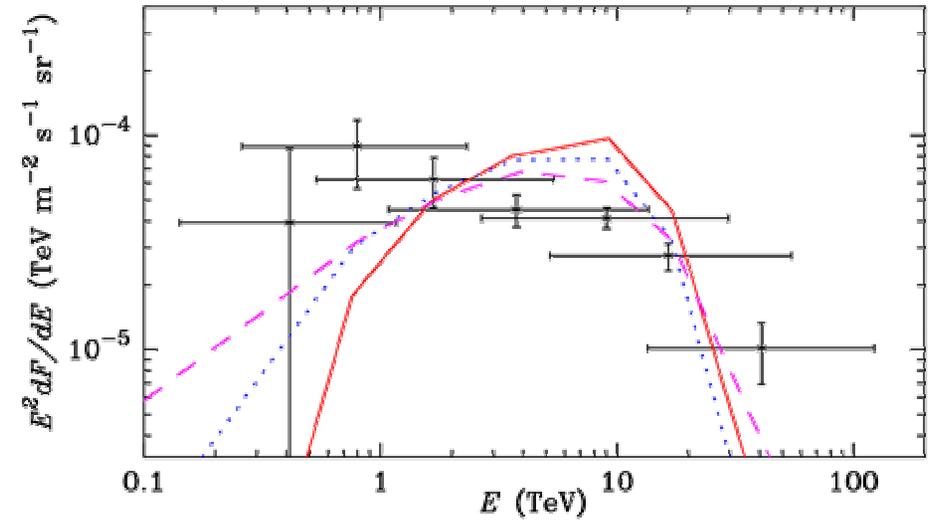
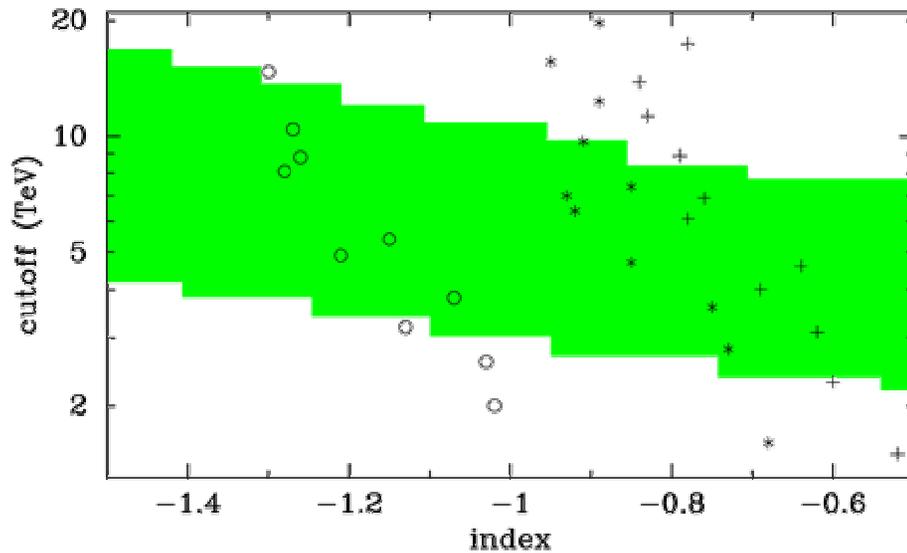


TeV CR Anisotropy

Milagro + IceCube TeV Cosmic Ray Data (10° Smoothing)



Anisotropy from DM



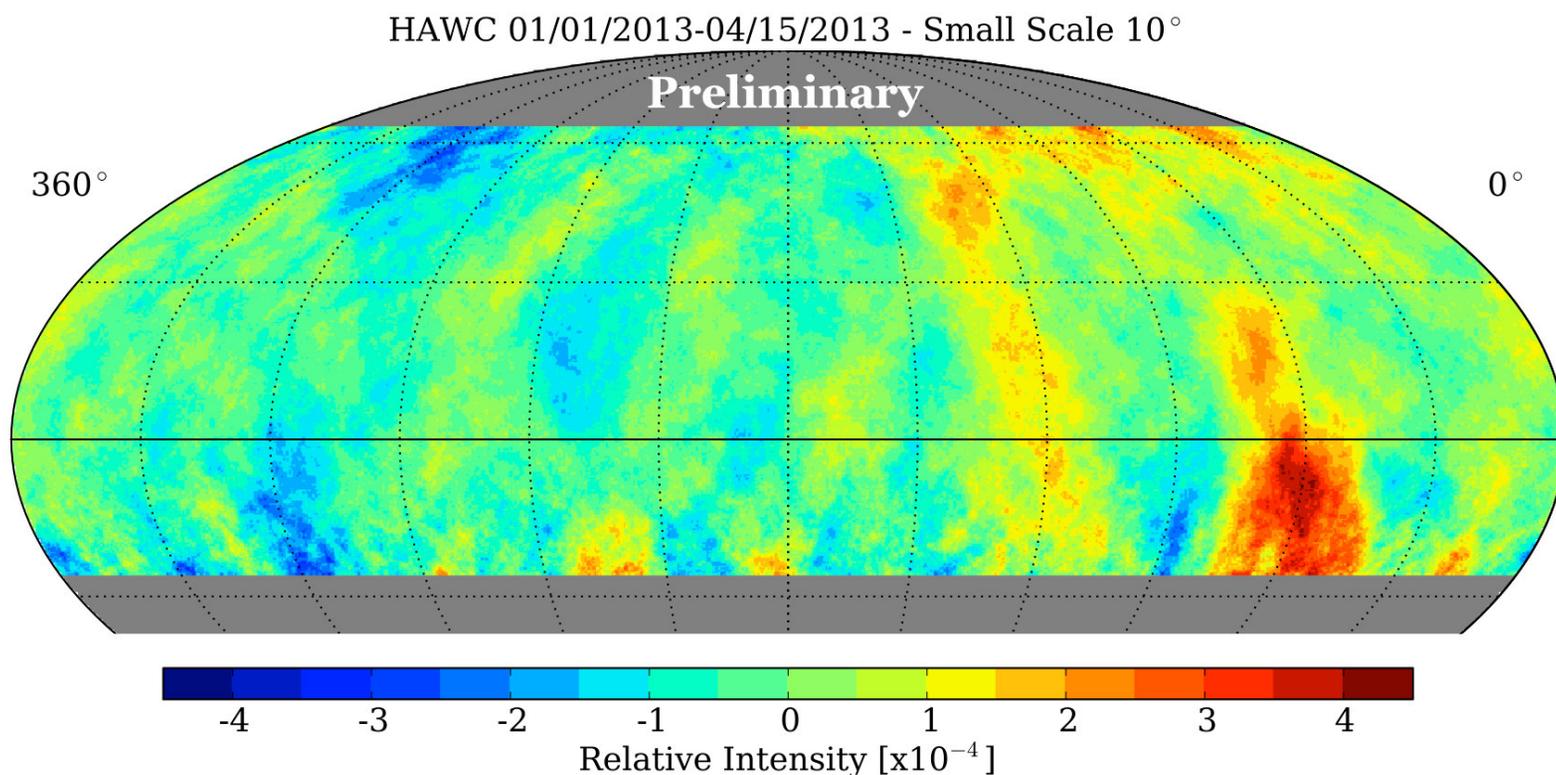


Constraints



- Meets all constraints:
 - Diffuse anti-protons (PAMELA, ARGO)
 - Diffuse positrons (AMS)
 - But pointed could detect it
 - All-sky gamma-rays (Fermi, Milagro)
 - For expected extended source
 - Pointed gamma-rays (HESS, VERITAS, MAGIC)
 - Would see it if they look at it
 - HAWC
 - Will detect it, if $\text{dec} > -30$

HAWC CR Anisotropy





Discussion



- HAWC will be fully operational by 2014 – but it is already taking data and making limits
- HAWC will make the most sensitive measurements of dark matter sources above 5 (50) TeV masses for the $\tau^+\tau^-$ ($b\bar{b}$) channel with wide field-of-view
- TeV cosmic-ray anisotropy can be coming from annihilating high-mass dark matter
- HAWC will observe a local dark matter subhalo producing the anisotropy
- HAWC will observe and constrain the cosmic-ray anisotropy to much better precision



Appendix



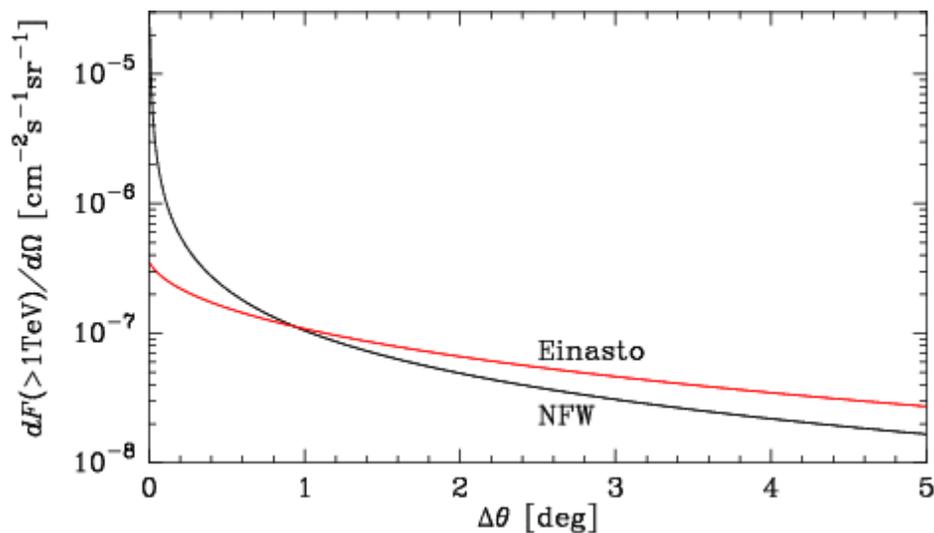
Dark Matter Flux

$$\text{Flux} \propto \frac{\langle \sigma v \rangle}{M_\chi^2} \frac{dN_\gamma}{dE} \int_{\text{l.o.s.}} dx \rho^2(r)$$

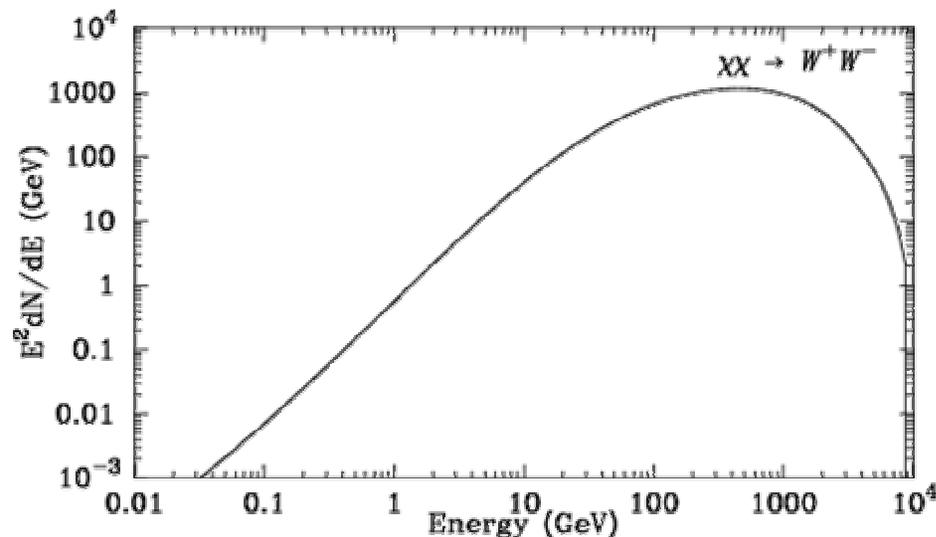
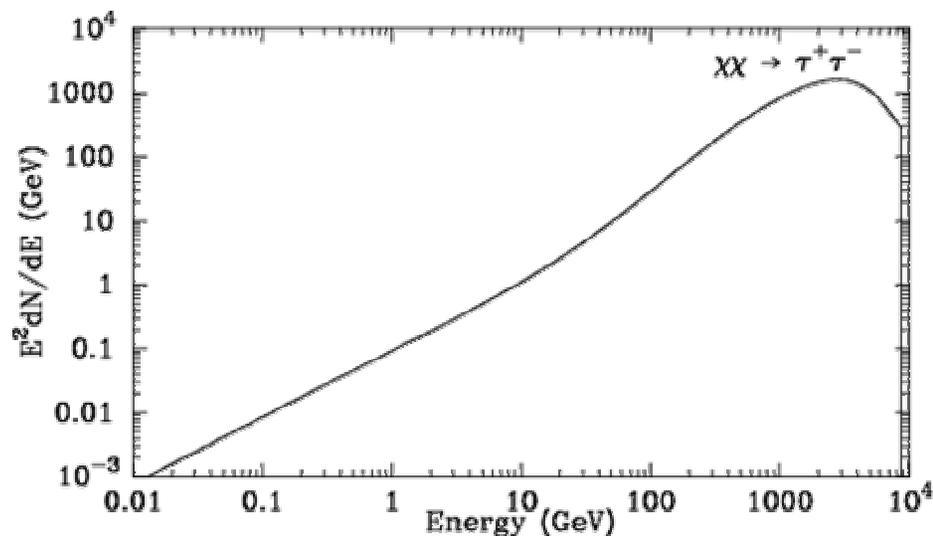
Largest density is at Galactic Center (dec=-29°)

For GC, density and optimal bin depend strongly on DM profile

For dwarf galaxies, flux is not very sensitive to DM profile



Dark Matter Spectra



- Gamma-ray spectra for two possible DM annihilation channels, (10 TeV DM mass).
- Can include power-law ($dN/dE \sim E^{-2}$) from inverse Comptonization of electron and positron annihilation products as well.
- Including IC emission improves limits at highest masses by factors of 2-5.